AUTOMATIC MAIN FAILURE (AMF) SYSTEM

SAIFUL ANUAR BIN ALWI

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Faculty of Electrical & Electronics Engineering
Universiti Malaysia Pahang

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In the name of Allah S.W.T, the Most Gracious, the Ever Merciful. Praise is to Allah, Lord of the Universe and Peace and Prayers be upon His Final Prophet and Messenger Muhammad S.A.W.

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ABSTRACT

Recently, solar energy has become one of the important alternative power supply for many devices due to the rises of fuel price. The limitedness of this kind of energy is its depend on the existence or the brightness of sunlight. This thesis presents a way to keep any 12V devices powered by solar power get the continuous power. The purposes of this project are to design and build a system that called Automatic Main Failure (AMF) System which can automatically allow switching from solar cell power supply to a battery as backup power supply. To execute this system, there are three main elements is used which are voltage sensor, microcontroller and relay switch. The system is continually monitoring the voltage level from solar cell. If the voltage is dropped below the allowed level, this system will switch the device to battery and switch back to solar cell when the level voltage is back to normal. If the voltage from solar cell is higher than allowed level, the voltage will be regulated to normal level through a voltage regulator. Thus the device will get a continuous power and protected from the effects of under-voltage and over-voltage.

ABSTRAK

Kebelakangan ini, tenage solar telah menjadi salah satu sumber tenaga alternatif yang penting akibat daripada kenaikan harga bahan bakar. Kelemahan sumber tenaga jenis ini adalah disebabkan kebergantungan kepada kehadiran atau kecerahan cahaya matahari. Tesis ini membentangkan mengenai satu cara untuk memastikan apa sahaja alatan bervoltan 12 volt yang menggunakan sel solar sebagai sumber tenaga mendapat tenaga yang berterusan. Projek ini adalah bertujuan mereka dan membina sebuah sistem yang dipanggil Sistem Kegagalan Utama Automatik yang mana secara automatiknya boleh memindahkan suis dari tenaga solar sel kepada bateri yang bertindak sebagai sumber tenaga sokongan. Bagi melaksanakan sistem ini, terdapat tiga elemen penting digunakan iaitu pengesan voltan, pengawal-mikro dan suis geganti. Sistem ini secara berterusan memerhati tahap voltan dari sel solar. Jika voltan jatuh dibawah tahap yang dibenarkan, sistem ini akan memindahkan sambungan alatan kepada bateri. Jika voltan dari sel solar melebihi tahap yang dibenarkan, voltan tersebut akan ditetapkan kepada keadaan normal menggunkan penetap voltan. Disebabkan itu, alatan akan mendapat tenaga yang berterusan dan dilindungi dari kesan akibat kekurangan voltan dan lebihan voltan.

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LIST OF ABBREVIATIONS

AMF	=	Automatic Main Failure
BJT	=	Bipolar Junction Transistor
IC	=	Integrated Circuit
LED	=	Light-Emitting Diode
LCD	=	Liquid Crystal Display

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CHAPTER 1

INTRODUCTION

1.1 Overview

Automatic Main Failure (AMF) System is a system by which can automatically transfer the switch from solar cell power supply to battery when anomaly such voltage drop, over-voltage and outage or blackout is occurred at the main power. AMF continually monitor the level of voltage at both power supplies but the priority is given to the solar cell as the main supply.

When the level of voltage is dropped below the normal condition, system will transfer the load from main power to battery as backup power to assure the load is continuously powered with allowed voltage level. And when the level of voltage is higher than the allowed voltage level, the power from solar cell will be regulated using the suitable voltage regulator to assure also the load get the proper level of voltage.

Voltage drop is the reduction in voltage in an electrical circuit between the source and load. In electrical wiring national and local electrical codes may set guidelines for maximum voltage drop allowed in a circuit, to ensure reasonable efficiency of distribution and proper operation of electrical equipment. [2]

When the voltage in a circuit or part of it is raised above its upper design limit, this is known as overvoltage. The conditions may be hazardous. Depending on its duration, the overvoltage event can be permanent or transient, the latter case also being known as a voltage spike. Electronic and electrical devices are designed to operate at a certain maximum supply voltage, and considerable damage can be caused by voltage that is higher than that for which the devices are rated. [3]

AMF system consists of three main elements which are voltage comparator, PIC microcontroller and relay switch. The voltage comparator is used to set and monitor the voltage level at both power supplies. The PIC microcontroller acts as the brain of the system that monitors the output signal from voltage comparator circuit and control the switching of relay accordingly. The relay is used to transfer the load either to the solar power as the main supply or to the battery as the backup supply.

1.2 Objectives

The objectives of this project are to:

i. Design a system that allows switching from solar power to backup power when anomaly is detected.
ii. Design an automatic system using PIC microcontroller

1.3 Scope

There are two areas or subjects matter that relevant to the project;

i. Software part that include processes of writing PIC program using MicroCode Studio software and simulate the system using ISIS Pro.

ii. Hardware part that include processes of interfacing the PIC microcontroller, voltage comparator and relay

1.4 Problem Statement

i. A device will not operate efficiently due to the voltage drop
ii. A device may damage due to overvoltage

1.5 Thesis Organization

This thesis consists of 7 chapters including this chapter. The content of each chapter are outlined as follows:

Chapter 1: Introducing the overview of project including the objective and scope of project.

Chapter 2: Introducing the background knowledge and literature review of voltage comparator, PIC microcontroller and relay.

Chapter 3: Include the project methodology. This will explain how the project was organized and the flow of system designed.

Chapter 4: The result will be analyzed and discussed.

Chapter 5: The overall conclusion of this project that have been completed.

CHAPTER 2

LITERATURE REVIEW

2.1 Voltage Comparator

A voltage comparator circuit consists of an operational amplifier, often called an op-amp, that compares input voltage and provides switches its digital output to indicate which is input is larger. A basic unit of voltage comparator circuit can be represented as in Figure 2.1. The output will stays at a high voltage level when the noninverting (+) input is greater than the voltage level at the inverting (-) input and switches to a lower voltage level when the noninverting input goes below the inverting input voltage.

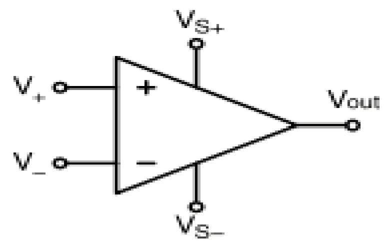
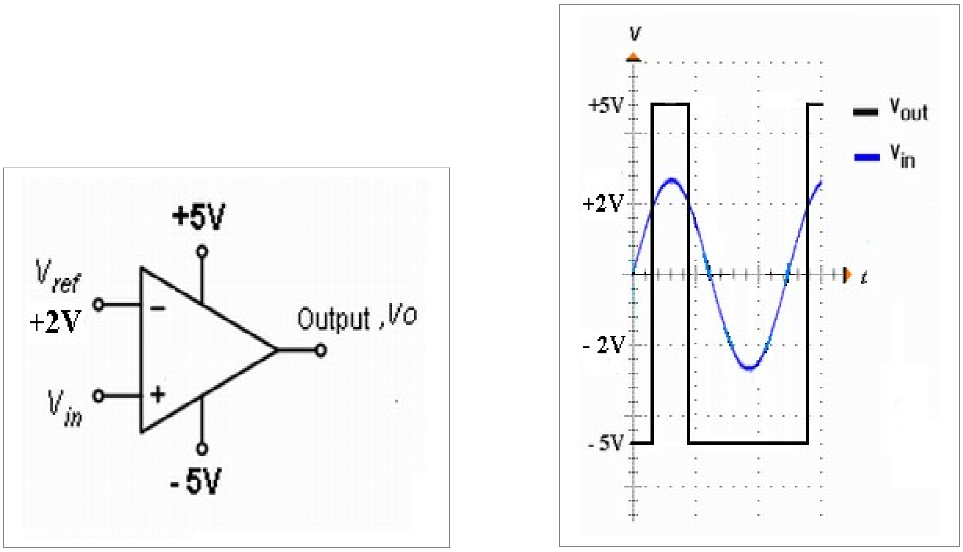


Figure 2.1 Basic unit of voltage comparator circuit

Figure 2.2a shows the example of typical connection with the inverting input connected to a reference voltage, the other connected to the input signal voltage. As long as V_{in} is less than the reference voltage level of +2V, the output remains at low voltage level. When the input is rises just above +2V, the output voltage quickly switches to a high voltage level. The waveform of the analog input signal and the digital output signal of the comparator unit in Figure 2.2a is shown in Figure 2.2b.



(b)

(a)

Figure 2.2 Operation of voltage comparator unit

Generally, the reference level can be any desired positive or negative or even zero voltage. Also, the reference voltage, V_{ref} may connected to either inverting or noninverting input terminal and the input signal, V_i then applied to the other input terminal.

2.2 PIC microcontroller

PIC (Peripheral Interface Controller) is the IC which was developed to control peripheral devices, alleviating the load from the main CPU (Control Processing Unit). Compared to a human being, PIC is equivalent to the autonomic nervous system.

The PIC, like the CPU, has calculation functions and memory, and is controlled by the software. However, the throughput and the memory capacity are low. Depending on the kind of PIC, the maximum clock operating frequency is about

20 MHz and the memory capacity to write the program is about 1000 to 4000 words. The clock frequency determines the speed at which a program is read and an instruction is executed. The throughput cannot be judged with the clock frequency alone. It changes with the processor architecture. However within the same architecture, the one with the highest clock frequency has the highest throughput.

The PIC is convenient for making calculations. The memory, the input or output ports and so on are incorporated into the IC (Integrated Circuit). The efficiency and the functions are limited, but the PIC can do the job of many IC's with software. So, the circuit can be compact.

2.3 Relay

A relay is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts. Because a relay is able to control an output circuit of higher power than the input circuit, it can be considered to be a form of an electrical amplifier.

Since relays are switches, the terminology applied to switches is also applied to relays. A relay will switch one or more poles, each of whose contacts can be thrown by energizing the coil in one of three ways:

i. Normally-open (NO) contacts connect the circuit when the relay is activated; the circuit is disconnected when the relay is inactive. It is also called a Form A contact or "make" contact.
ii. Normally-closed (NC) contacts disconnect the circuit when the relay is activated; the circuit is connected when the relay is inactive. It is also called a Form B contact or "break" contact.

The following designations are commonly encountered for relay:

i. SPST - Single Pole Single Throw. These have two terminals which can be connected or disconnected. Including two for the coil, such a relay has four terminals in total. It is ambiguous whether the pole is normally open or normally closed.

ii. SPDT - Single Pole Double Throw. A common terminal connects to either of two others. Including two for the coil, such a relay has five terminals in total.

iii. DPST - Double Pole Single Throw. These have two pairs of terminals. Equivalent to two SPST switches or relays actuated by a single coil. Including two for the coil, such a relay has six terminals in total.

iv. DPDT - Double Pole Double Throw. These have two rows of change-over terminals. Equivalent to two SPDT switches or relays actuated by a single coil. Such a relay ha

CHAPTER 3

METHODOLOGY

3.1 Overall System Design

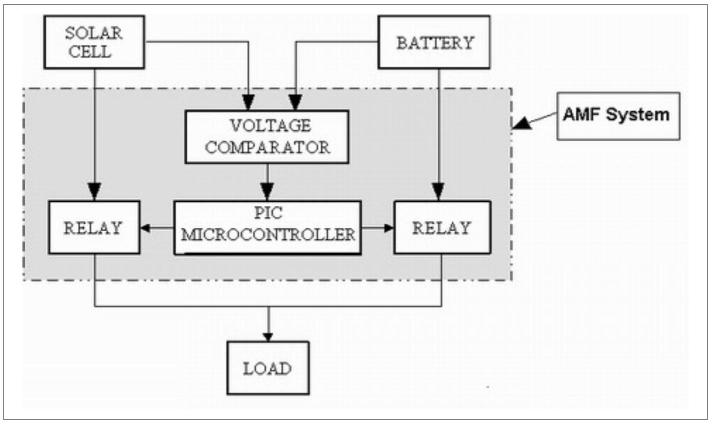
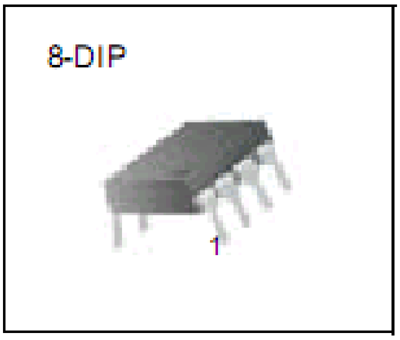


Figure 3.1 Block Diagram of the System

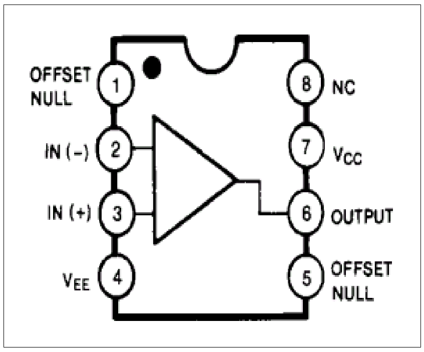
The block diagram in Figure 3.1 shows the interconnection of main elements in AMF systems which are voltage comparator, PIC microcontroller and relay switch.

3.2 Setting Up The Level Of Voltage

Voltage comparator usually used to set a level of voltage, both high and low. In this project, LM741 is used to implement the comparator circuit due to its low price, easiness to find and robust to heat. Figure 3.2 shows the configuration of LM741. The LM741 are general purpose operational amplifiers. It is intended for a wide range of analog applications. The high gain and wide range of operating voltage provide superior performance in integrator, summing amplifier, and general feedback applications.



(a)



(b)

Figure 3.2 Configuration of LM741

The Figure 3.2a shows the actual LM741 while Figure 3.2b shows the internal block diagram of LM741. Pin 2 and pin 3 are the input pins while pin 6 is the output pin. Pin 8 is used for power supply and pin 4 is used for grounding. Pin 1 and pin 5 are not used and offset null. The incoming inputs are either from solar cell or battery. The voltage inputs must not exceeded the voltage of power supply. The power supply for the LM741 in this project provides 12V power.

The steps to set up the voltage level are started with select the voltage level for low level and high level. For low level the voltage reference is set to be 9V and for the high level voltage reference is set to be 15V.

3.2.1 Voltage Divider Circuit

Since the voltage for both power supply and the incoming inputs are the same, a simple voltage divider circuit is used to step down the inputs voltage. Figure 3.2.1a shows the simple voltage circuit. The input voltage that will enter the system at normal condition has been decided to be 5V. Then, the value both resistors, R_1 and R_2 need to find.

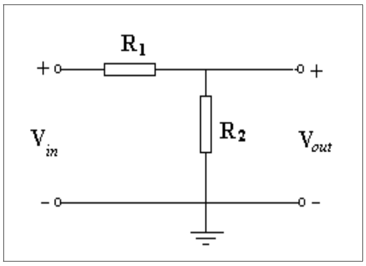


Figure 3.2.1a Simple Voltage Divider Circuit

Let assume resistor R_2 is 1kΩ, and then the value of R_1 can be find as follows;

$$V_{output} = \frac{R_2}{(R_1 + R_2)} V_{input}$$

After rearranged, the formula became;

$$R_1 = \left(\frac{R_2}{V_{output}} V_{input}\right) - R_2$$

$$R_1 = \left(\frac{(1.2\mathrm{k}\,\Omega)}{5\mathrm{V}} 12\mathrm{V}\right) - 1.2\mathrm{k}\,\Omega$$

$$R_1 = 1.68\mathrm{k}\,\Omega$$

Since there is no resistor with value 1.68kΩ is sold in the market, the value of R_1 will be a combination of resistors 1.5kΩ and 180Ω. The circuit then will be such Figure 3.2.1b.

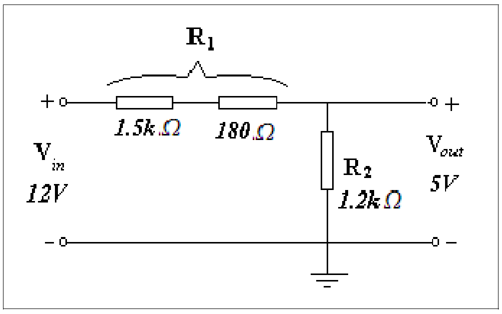


Figure 3.2.1b The Actual Voltage Divider Circuit

3.2.2 Low Level Voltage Setting

To set the low level input voltage, the following step is used; Firstly, the 9V low level voltage reference will be step down as it goes through the voltage divider circuit in Figure 3.2.2.

$$V_{low} = \frac{R_2}{(R_1 + R_2)} V_{input}$$

$$V_{low} = \frac{(1\text{k}\Omega)}{(1.4\text{k}\Omega + 1\text{k}\Omega)} 9\text{V}$$

$$V_{low} = 3.75\text{V}$$

Then, the low level voltage reference for the comparator in Figure 3.2.3 is set using the following step;

$$V_{low} = \frac{R_4}{(R_3 + R_4)} V_S$$

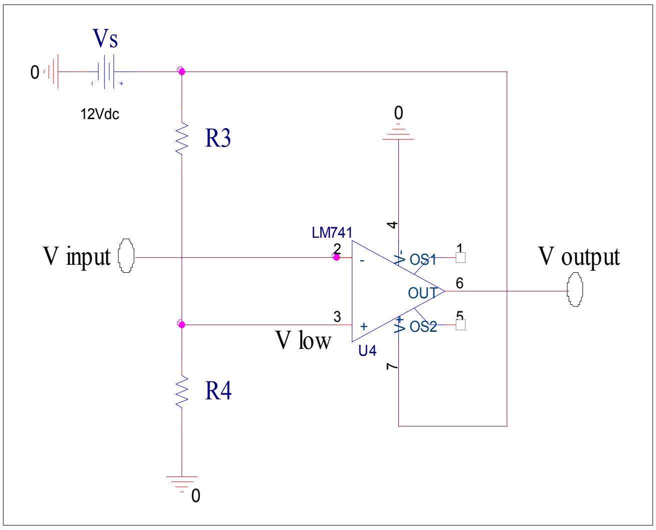


Figure 3.2.2 Low Level Voltage Comparator

Let assume the value for resistor R_4 is 20kΩ, hence the value for R_3 is

$$R_3 = (V_s \frac{R_4}{V_{low}}) - R_4$$

$$R_3 = (12\text{V} \frac{(20\text{k}\,\Omega)}{3.75\text{V}}) - 20\text{k}\,\Omega$$

$$R_3 = 44\text{k}\,\Omega$$

In actual, there is no resistor 44kΩ is sold in the market, thus the value for resistor R3 is chose to be 47kΩ and the low level voltage reference then to be;

$$V_{low} = \frac{(20\text{k}\,\Omega)}{(47\text{k}\,\Omega + 20\text{k}\,\Omega)} 12\text{V}$$

$$V_{low} = 3.58\text{V}$$

Since the input voltage is step down using voltage divider, the input voltage at low level is;

$$V_{input} = \frac{(R_1 + R_2)}{R_2} V_{low}$$

$$V_{input} = \frac{(1.4\text{k}\,\Omega + 1\text{k}\,\Omega)}{(1\text{k}\,\Omega)} 3.58\text{V}$$

$$V_{low} = 8.59\text{V}$$

3.2.3 High Level Voltage Setting

To set the high level input voltage, the following step is used; Firstly, the 15V low level voltage reference will be step down as it goes through the voltage divider circuit in Figure 3.2.2.

$$V_{high} = \frac{R_2}{(R_1 + R_2)} V_{input}$$

$$V_{high} = \frac{(1\text{k}\,\Omega)}{(1.4\text{k}\,\Omega + 1\text{k}\,\Omega)} 15\text{V}$$

$$V_{high} = 6.25\text{V}$$

Then, the high level voltage reference for the comparator in Figure 3.2.3 is set using the following step;

$$V_{high} = \frac{R_6}{(R_5 + R_6)} V_S$$